

**Remarks/Arguments**

Applicant respectfully requests favorable reconsideration of the subject application, particularly in view of the above amendment and the following remarks. There is no additional fee for this amendment as the number of independent claims and the total number of claims remain unchanged.

On 03 October 2007, a telephone interview was conducted by the undersigned with the Examiner and Examiner Tracy Dove during which three issues were addressed. The first of these issues relates to the rejection of claims under 35 U.S.C. 112, second paragraph; the second of these issues relates to the patentable weight to be given to the preamble of a claim; and the third of these issues relates to applicability of the prior art relied upon for rejection of the subject application and motivation for one skilled in the art to apply the teachings of the secondary reference to the teachings of the primary reference to render the claimed invention obvious. Regarding the first of these issues, the Examiner withdrew the rejection. Regarding the second of these issues, in light of MPEP §608.01(m) relating to the patentability weight to be given to the preamble of a Jepson claim, the Examiner agreed that all of the elements of the preamble of the rejected independent claims would be given patentable weight. Regarding the third of these issues, the Examiner's position is that it would be obvious to apply the teachings of the secondary reference to the teachings

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of the primary reference on the basis that the material taught by the secondary reference is an electron and proton conductive material, notwithstanding the fact that it contains a component, i.e. lignin, which is not shown by either the primary or secondary reference to be suitable for use in a fuel cell. It was also the position of the Examiner that direct methanol fuel cells, in which the fuel is methanol, are structurally equivalent to polymer electrolyte membrane fuel cells in which the fuel is hydrogen such that teachings relating to the structure of the latter are applicable to the former. No agreement was reached on this latter issue.

Applicant has amended Claim 1, line 7 by adding a comma after "layer". Applicant has similarly amended Claim 40, line 7 by adding a comma after "layer". Applicant respectfully urges that this amendment to Claims 1 and 40 is solely for the purpose of correcting a typographical error and, thus, incorporates no new subject matter into the claims.

Claims 1-14 have been rejected under 35 U.S.C. 112, second paragraph as failing to define the invention in the required manner. This rejection is rendered moot as a result of the withdrawal of the rejection by the Examiner during the telephone interview discussed herein above.

The invention claimed by Applicant is a fuel cell comprising an anode electrode, a cathode electrode and a proton exchange membrane electrolyte disposed

there between. An anode catalyst layer is disposed on the electrolyte facing surface of the anode electrode or the anode electrode facing surface of the electrolyte. The anode catalyst layer comprises a proton conductive material and an electron conductive material substantially uniformly dispersed throughout the catalyst layer. At least one of the proton conductive material and the electron conductive material comprises lignin. In accordance with one embodiment of this invention, the lignin may be in the form of ligno-sulfonic acid. In accordance with an alternative embodiment of this invention, the lignin is part of a grafted polymer, e.g. polyaniline grafted to lignin. In accordance with one embodiment, the fuel cell is a direct methanol fuel cell. Applicant respectfully urges that the prior art relied upon by the Examiner for rejection of the subject application neither teaches nor suggests a fuel cell or a direct methanol fuel cell comprising an anode electrode having an anode catalyst layer comprising a proton conductive material and an electron conductive material substantially uniformly dispersed throughout the catalyst layer where the proton conductive material and/or the electron conductive material comprises lignin as claimed by Applicant.

Claims 1-14 and 40 have been rejected under 35 U.S.C. 103(a) as being unpatentable over Srinivas, U.S. Patent Publication No. 2004/0110051 A1 (hereinafter "the Srinivas publication") in view of Tripathy et al., U.S. Patent Publication No.

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2002/0183470 (hereinafter “the Tripathy et al. publication”). This rejection is respectfully traversed. The Srinivas publication teaches a composition comprising particulate carbonaceous material and a sulfonated conducting polymer containing hetero atoms. Devices comprising the composition, which may include a metal, include supported electrocatalysts, membrane electrode assemblies and fuel cells. However, *the Srinivas publication neither teaches nor suggests an anode catalyst comprising lignin* as claimed by Applicant, a fact acknowledged by the Examiner. The Tripathy et al. publication teaches a method for polymerization of aromatic monomers using derivatives of hematin including assembled hematin. In one embodiment, the polymerization is carried out in the presence of a template, along which aromatic monomers align. Assembled hematin includes alternating layers of hematin and a polyelectrolyte, which are deposited on an electrically charged substrate (Abstract). The Tripathy et al. publication also teaches the use of electrically conductive polymers in a variety of electronic devices including electro-chromic devices, light-emitting diodes, electrostatic discharge protection, and light weight batteries (Paragraph [0003]). *Nowhere does the Tripathy et al. publication teach the use of electrically conductive polymers comprising lignin in fuel cells.* In addition, the Tripathy et al. publication also teaches a method for producing lignosulfonate-Pani complex using hematin (Paragraph [0069]). *Nowhere does the Tripathy et al.*

*publication teach or suggest the use of a lignosulfonate-Pani complex as part of an anode catalyst layer which is both proton and electron conductive employed in a fuel cell as claimed by Applicant.* Applicant further respectfully urges that the Tripathy et al. publication does not teach or suggest the use of a lignosulfonate-Pani complex as a component of a proton conductive material in accordance with certain embodiments of the invention claimed by Applicant. Thus, Applicant respectfully urges that it is mere conjecture on the part of the Examiner as to the suitability of a lignosulfonate-Pani complex for use in the anode catalyst layer of a fuel cell as claimed by Applicant.

The Examiner states:

"In regard to claims 1-11, 40, the Srinivas reference discloses a fuel cell with an anode catalyst layer comprising a proton conductive material made of sulfonic acid (Paragraph 22). The Srinivas reference discloses a grafted sulfonated polyaniline and a polypyrrole ionomer that is electrically conductive and dispersed throughout a carbon support in fuel cell catalysts (Paragraph 41 and Paragraph 30), however, the Srinivas reference does not disclose a material comprising lignin. The Tripathy et al. reference discloses the use of another form of polyaniline, or more specifically, polyaniline-lignin sulfonate complexes (Paragraph 25) which are used as catalyst disposed on electrically charged substrates (Abstract) in lightweight battery (Paragraph 3). The Tripathy reference further disclose (sic) these polyaniline-lignin sulfonate complexes are water soluble virtually eliminating the need for toxic reagents and solvents, and thus creating an

environmentally friendly synthesis (Paragraph 14), therefore it would have been obvious to one of ordinary skill to place catalyst such as polyaniline-lignin sulfonate complexes disclosed by Tripathy into another electrochemical device such as the fuel cell; the fuel cell utilizes a sulfonated polyaniline catalyst layer as disclosed by Srinivas in order to create a light weight electrochemical cell without environmental hazards. It is well known in the art that a PEM fuel cell and battery are electrochemical devices having (sic) anodes, cathodes and a proton exchange membrane electrolyte. The PEM fuel cell and battery are therefore functional equivalence (sic). The substitution of known equivalent structures involves only ordinary skill in the art.”

That is, according to the Examiner, because batteries and PEM fuel cells are both electrochemical devices having anodes, cathodes and proton exchange membrane electrolytes, batteries and PEM fuel cells are functionally equivalent. Thus, the Examiner argues that teachings with respect to batteries (as set forth in the Tripathy et al. publication) are applicable to PEM fuel cells and, thus, the invention claimed by Applicant involves nothing more than ordinary skill in the art. Applicant respectfully disagrees.

Applicant respectfully urges that *fuel cells and batteries are not functional equivalents as asserted by the Examiner*. MPEP § 2144.06 states:

“In order to rely on equivalence as a rationale supporting an obviousness rejection, *the equivalency must be recognized in the prior art, and cannot be based on applicant's disclosure or the mere fact that the*

*components at issue are functional or mechanical equivalents* (emphasis added)."

Thus, Applicant respectfully urges that *merely because batteries and PEM fuel cells both may have anodes, cathodes, and proton exchange membrane electrolytes does not make batteries and PEM fuel cells functional equivalents.* Applicant respectfully urges that a fuel cell, although having components and characteristics similar to those of a typical battery, differs in several respects, a fact known to those skilled in the art and expressed in the prior art. For one thing, it is well known to those skilled in the art that *a battery is an energy storage device.* The maximum energy available from a battery is determined by the amount of chemical reactant stored within the battery itself. The battery will cease to produce electrical energy when the chemical reactants are consumed (i.e. when the battery is discharged). In a secondary battery, the reactants are regenerated by recharging, which involves putting energy into the battery from an external source. In direct contrast thereto, it is also well known to those skilled in the art that *a fuel cell is an energy conversion device* that theoretically has the capability of producing electrical energy for as long as the fuel and oxidant are supplied to the electrodes. In reality, degradation, primarily corrosion, or malfunction of components limits the practical operating life of fuel cells. Thus, the electrochemical environment as well as the operating conditions of a battery *are substantially different* from the electrochemical environment and operating conditions

of a fuel cell. As a result, to the extent that batteries may use catalytic electrodes, longevity of the catalyst is not an issue because the life expectancy of batteries is very limited. In contrast thereto, the longevity of a catalyst in a continuously operating fuel cell having potentially unlimited life expectancy is a critical issue. In addition, in a fuel cell, the electrodes are used to convert a fuel, such as hydrogen or methanol, to electricity and, thus, must be able to perform this function. In contrast thereto, batteries do not convert fuels to electricity and, indeed, do not have the means for such conversion. Thus, the function of the electrodes of a battery is very different from the function of the electrodes of a fuel cell. Given these differences in functionality between a battery and a fuel cell, Applicant respectfully urges that teachings relating to materials suitable for use in battery electrodes are not readily applicable to fuel cell electrodes and the materials suitable for use therein.

As a result of the telephone interview discussed herein above, Applicant further understands the Examiner's argument to be that because the Srinivas publication teaches the use of sulfonated conducting polymer-grafted carbons in fuel cells employing conducting polymers such as sulfonated polyaniline, and because the Tripathy et al. publication teaches an electrically conductive material which is a lignin sulfonate polyaniline complex (Paragraph [0069], it would be obvious to one of ordinary skill in the art at the time of the invention to use the material of the Tripathy

et al. publication in a fuel cell as claimed by Applicant. The only motivation articulated by the Examiner as understood by Applicant is that the material of the Tripathy et al. publication is electrically conductive and fuel cells employ electrically conductive materials. Applicant respectfully urges that the motivation as articulated by the Examiner ignores the presence of a component in the polymer of the Tripathy et al. publication, i.e. lignin, which, until the invention of Applicant, has never been used in a fuel cell, thus suggesting that any material having some compositional component of known fuel cells which is electrically conductive is suitable for use in a fuel cell, including direct methanol fuel cells as claimed by Applicant, and provides the improvements exhibited by the fuel cells claimed in the subject application. That is, based upon the motivation for combining the teachings of the Srinivas and Tripathy et al. publications, any sulfonated polymer that is electrically conductive, regardless of any additional elements or compounds which form the polymer, is suitable for use in the anode catalyst of a fuel cell. Applicant respectfully disagrees.

Applicant respectfully urges that fuel cell performance is the true measure of the suitability of a material for use in a fuel cell, not merely the fact that the material in question happens to be electronically conductive. Thus, while the prior art relied upon by the Examiner for rejection of the subject application clearly establishes that sulfonated polyaniline is suitable for use as an electrode catalyst, none

of the prior art teaches or suggests that the grafting of lignin, a material which, prior to the invention claimed by Applicant, has not been used in the anode catalyst of a fuel cell, to a sulfonated polyaniline polymer will result in an electrically conductive material suitable for use *under the operating conditions of a fuel cell*, including direct methanol fuel cells, *which provides the performance improvements described by Applicant*. The Examiner further articulated that because the specification of the subject application is limited in its description of the benefits afforded by the grafting of lignin to the sulfonated polyaniline polymer, lignin does not play a significant role and, thus, can effectively be discounted as having been added by Applicant solely for the purpose of circumventing the prior art. The Examiner further articulated that hydrogen-fueled polymer electrolyte membrane fuel cells are structurally the same as direct methanol fuel cells and, thus, the fact that one of the embodiments of the invention claimed by Applicant is a direct methanol fuel cell is irrelevant with respect to establishing the patentability of Applicant's claimed invention.

Beginning with the last two lines on Page 5 of the subject application, the specification states as follows:

"The invention claimed herein comprises a modification to the anode catalyst ink layer to increase electron and proton conduction within the device and to reduce methanol transport. Methanol molecules are hindered or prevented from passing through the modified catalyst layer, thereby reducing or eliminating methanol reach

into or crossover through the polymer electrolyte membrane. The anode catalyst layer is modified by the dispersal of a binder material throughout the layer comprising both an electronically conductive material and a proton conductive material and lignin. In accordance with one preferred embodiment of this invention, the binder material is polyaniline ink, which is a long chain, grafted to lignin. Advantages of this ink in accordance with one embodiment of this invention include (1) the use of ligno-sulfonic acid and *para*-toluene sulfonic acid as dopants where the sulfonic acid in the polymer enables proton conductivity; (2) the use of polyaniline, which is a good electron conductor and which enables the electrons resulting from the oxidation of methanol to transfer to the external circuit; (3) corrosion resistance and adhesiveness, which add to stable bonding of the layer; (4) stability under oxidation and reduction conditions because the ink contains a grafted polymer; and (5) improvement in the overall catalytic efficiency because the ink is both electron and proton conductive, thereby reducing the restriction on the transport of the methanol reaction products, such as protons through the electrolyte membrane and electrons to the external circuit."

As clearly stated, the anode catalyst ink layer employed in the invention claimed by Applicant, which layer comprises an electronically conductive material and a proton conductive material *and lignin*, increases electron and proton conduction within the device and it reduces methanol transport or crossover through the polymer electrolyte membrane of the claimed direct methanol fuel cell. It also provides improvements in corrosion resistance and adhesiveness as well as stability under oxidation and reduction conditions. Applicant respectfully urges that attribution of

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portions of the improved performance to specific components of the sulfonated polyaniline polymer grafted with lignin is not a requirement for establishing patentability.

Claim 14 of the subject application states:

“A fuel cell in accordance with Claim 1, wherein said electron conductive material comprises in a range of about 5% by weight to about 20% by weight of said anode catalyst layer.”

The Examiner argues that this limitation is met by the teachings of paragraph [0136] of the Srinivas publication, which discloses the sulfonated group per monomer unit on the polymer ranges from 0.2-2.9. Applicant respectfully urges that nothing in the recitation of the Srinivas publication cited by the Examiner teaches a fuel cell having an anode catalyst layer in which the electron conductive material comprises in the range of about 5% to about 20% as claimed by Applicant.

In summary, for the reasons set forth herein above, Applicant respectfully urges that the Srinivas publication and the Tripathy et al. publication, alone or in combination, do not render Applicant's claimed invention obvious in the manner required by 35 U.S.C. 103(a).

#### **Response to Examiner's Arguments**

The Srinivas publication is relied upon by the Examiner as teaching a grafted sulfonated polyaniline polymer which is both electron and proton conductive.

The Tripathy et al. publication is relied upon by the Examiner as teaching that sulfonated polyaniline can contain lignin in the compound and, thus, "provided motivation fro (sic) use of sulfonated polyaniline-lignin." Other than the fact that sulfonated polyaniline-lignin is both electron and proton conductive, the Examiner has not articulated any motivation for the use of this material in the anode catalyst of a fuel cell. In broad terms, the invention claimed by Applicant involves the use of an electron and proton conductive polymer comprising lignin for the purpose of improving the performance of polymer electrolyte membrane fuel cells with respect to increasing electron and proton conduction within the device, reducing methanol transport or crossover through the polymer electrolyte membrane of direct methanol fuel cells, improving corrosion resistance and adhesiveness as well as stability under oxidation and reduction conditions (Page 5, line 20 - Page 6, line 17 of the specification of the subject application). Applicant respectfully urges that the motivation articulated by the Examiner is not sufficient, particularly because it can be applied to virtually any electron and proton conductive polymer. That is, no motivation is articulated by the Examiner for the addition of lignin as claimed by Applicant to an electron and proton conductive material which is known to be suitable for use in polymer electrolyte membrane fuel cells. The Tripathy et al. publication teaches such a material, but neither teaches nor suggests any motivation for using this

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material in a fuel cell as claimed by Applicant. For example, there is no indication in the Tripathy et al. publication of improved electron and proton conductivity associated with this material nor is there any other indication of improvements to be derived from the use of this material in a fuel cell as claimed by Applicant, nor is there any indication of any other problem that would be solved by the use of this material in a fuel cell as claimed by Applicant.

MPEP §2143.01 1 states:

“Obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either explicitly or implicitly in the references themselves or in the knowledge generally available to one of ordinary skill in the art. “The test for an implicit showing is what the combined teachings, knowledge of one of ordinary skill in the art, and the nature of the problem to be solved as a whole would have suggested to those of ordinary skill in the art.” *In re Kotzab*, 217 F.3d 1365, 1370, 55 USPQ2d 1313, 1317 (Fed. Cir. 2000). See also *In re Lee*, 277 E3d 1338, 1342-44, 61 USPQ2d 1430, 1433-34 (Fed. Cir. 2002) (discussing the importance of relying on objective evidence and making specific factual findings with respect to the motivation to combine references); *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988); *In re Jones*, 958 F.2d 347, 21 USPQ2d 1941 (Fed. Cir. 1992).”

Accordingly, absent such a motivation for combining the teachings of the primary and secondary references relied upon by the Examiner for rejection of the subject

application, Applicant respectfully urges that the combination of the teachings of these references is not sufficient to render Applicant's claimed invention obvious in the manner required by 35 U.S.C. 103(a).

Previously, the Examiner argued:

"It is well known in the art that a PEM fuel cell and battery are electrochemical devices with anodes, cathodes and a proton exchange membrane electrolyte. The PEM fuel cell and battery are therefore functional equivalence (sic). The substitution of known equivalent structures involves ordinary skill in the art."

That is, according to the Examiner, because batteries and PEM fuel cells are both electrochemical devices having anodes, cathodes and proton exchange membrane electrolytes, batteries and PEM fuel cells are functionally equivalent. Thus, the Examiner argues that teachings with respect to batteries (as set forth in the Tripathy et al. publication) are applicable to PEM fuel cells and, thus, the invention claimed by Applicant involves nothing more than ordinary skill in the art. In response to this argument, Applicant urged that fuel cells and batteries are not functional equivalents, but rather they are very different, and, thus, teachings relating to the use of a material in a battery would not motivate one skilled in the art to use a material which has been found to be suitable for use in a battery in a fuel cell.

Applicant respectfully urges that the differences between fuel cells as claimed by Applicant and batteries as taught by the Tripathy et al. publication are

significant such that one skilled in the art would not be motivated to apply teachings relating to materials used in the anodes of batteries to fuel cell anodes. As previously argued by Applicant, a fuel cell, although having certain components and characteristics similar to those of a typical battery, differs in several respects, a fact known to those skilled in the art and expressed in the prior art. For one thing, it is well known to those skilled in the art that *a battery is an energy storage device*. The maximum energy available from a battery is determined by the amount of chemical reactant stored within the battery itself. The battery will cease to produce electrical energy when the chemical reactants are consumed (i.e. when the battery is discharged). In a secondary battery, the reactants are regenerated by recharging, which involves putting energy, in the form of electricity, into the battery from an external source. Also as is well known to those skilled in the art, although electricity is a form of energy, electricity is not a fuel. In direct contrast thereto, it is well known to those skilled in the art that *a fuel cell is an energy conversion device* that theoretically has the capability of producing electrical energy for as long as the fuel and oxidant are supplied to the electrodes. In reality, degradation, primarily corrosion, or malfunction of components limits the practical operating life of fuel cells. Thus, the electrochemical environment as well as the operating conditions of a battery *are substantially different* from the electrochemical environment and

operating conditions of a fuel cell. As a result, to the extent that batteries may use catalytic electrodes, longevity of the catalyst is not an issue because the life expectancy of batteries is very limited. In contrast thereto, the longevity of a catalyst in a continuously operating fuel cell having potentially unlimited life expectancy is a critical issue. In addition, in a fuel cell, the electrodes are used to convert a fuel, such as hydrogen or methanol, to electricity and, thus, must be able to perform this function. In contrast thereto, batteries do not convert fuels to electricity and, indeed, do not have the means for such conversion. Thus, the function of the electrodes of a battery is very different from the function of the electrodes of a fuel cell. Finally, the performance criteria of a fuel cell are substantially different from those of a battery. Thus, teachings relating to the use of a given material in a battery would not be used by one skilled in the art in connection with a fuel cell given the substantial differences in performance criteria and further given the absence of any indication, as in the instant case, that the material in question will not negatively impact the performance of the fuel cell. Accordingly, for the reasons set forth herein above, Applicant respectfully urges that the Srinivas publication and the Tripathy et al. publication, alone or in combination, do not render Applicant's claimed invention obvious in the manner required by 35 U.S.C. 103(a).

The Examiner further argues that, while Applicant's arguments address batteries and fuel cells as not being functional equivalents, Applicant did not argue or provide evidence as to why one of ordinary skill in the art would not combine lignin in sulfonated polyaniline as taught by the Tripathy publication to the grafted sulfonated polyaniline in an anode as taught by the Srinivas publication. Applicant respectfully urges that the Examiner must first articulate a valid motivation for one skilled in the art to combine the references, which motivation Applicant respectfully urges has not been provided.

As articulated during the telephone interview of 03 October 2007, it is the position of the Examiner that direct methanol fuel cells, in which the fuel is methanol, are structurally equivalent to polymer electrolyte membrane fuel cells in which the fuel is hydrogen such that teachings relating to the structure of the latter are applicable to the former. Applicant respectfully disagrees.

Whereas a conventional polymer electrolyte membrane fuel cell utilizes hydrogen as a fuel, the direct methanol fuel cell is a polymer electrolyte membrane fuel cell that is fed with an aqueous solution of methanol. Contrary to the hydrogen-fueled fuel cell in which hydrogen fed to the anode is converted to H<sup>+</sup>, which is transported from the anode electrode through the polymer electrolyte membrane, the aqueous methanol fed to the anode electrode diffuses through a diffusion layer to a

catalytic layer where it is electrochemically oxidized into mainly carbon dioxide and six protons (as hydronium ions) plus six electrons. The protons formed during the electrochemical oxidation diffuse through the polymer electrolyte membrane to the cathode catalytic layer where they participate in oxygen reduction to form water at the cathode side. Issues associated with direct methanol fuel cells to which hydrogen-fueled fuel cells are not prone include slow electro-oxidation kinetics and methanol crossover from the anode to the cathode side of the electrolyte membrane. Regarding the electro-kinetics, various surface intermediates are formed during methanol electro-oxidation. Methanol is mainly decomposed to CO which is then further oxidized to  $\text{CO}_2$ . Other CO-like species are also formed:  $\text{COH}_{\text{ads}}$ ,  $\text{HCO}_{\text{ads}}$ ,  $\text{HCOO}_{\text{ads}}$ . Principle by-products are formaldehyde and formic acid. Some of these intermediates are not readily oxidizable and remain strongly adsorbed to the catalyst surface. Consequently, they prevent fresh methanol molecules from adsorbing and undergoing further reaction. Thus, electro oxidation of intermediates is a rate limiting step. Regarding methanol crossover, one of the objectives of the membrane of a polymer electrolyte membrane fuel cell is to prevent fuel and oxygen from crossing over to the opposite electrode. In direct methanol fuel cells, the fuel is known to diffuse through NAFION membranes which are normally employed in polymer electrolyte membrane fuel cells. Accordingly, the structure of a direct methanol fuel cell is necessarily different from

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the structure of a conventional hydrogen-fueled polymer electrolyte membrane fuel cell in order to address these issues. As stated in the subject application, one of the issues addressed by Applicant's claimed invention is the reduction or elimination of methanol crossover in direct methanol fuel cells.

### **Conclusion**

Applicant intends to be fully responsive to the outstanding Office Action. If the Examiner detects any issue which the Examiner believes Applicant has not addressed in this response, Applicant urges the Examiner to contact the undersigned.

Applicant sincerely believes that this patent application is now in condition for allowance and, thus, respectfully requests early allowance.

Respectfully submitted,



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